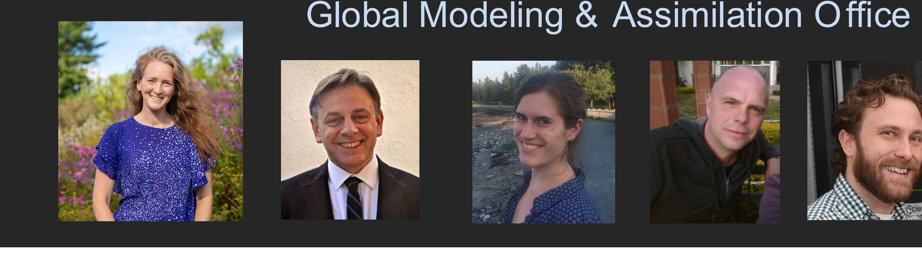
Bridging the SAGE data gap: Toward a climate data product with ozone and water vapor data from NASA SAGE and Aura missions and NASA reanalyses

K. Emma Knowland[1,2], Steven Pawson[2], Pam Wales[1,2], Krzysztof Wargan[2,4] and Brad Weir[1,2]

1 Morgan State University/GESTAR-II, 2 Global Modeling and Assimilation Office (GMAO), NASA/GSFC, 3 Atmospheric Chemistry and Dynamics Laboratory, NASA/GSFC, 4 Space Systems and Applications, Inc. (SSAI)

GMAO Global Modeling & Assimilation Office



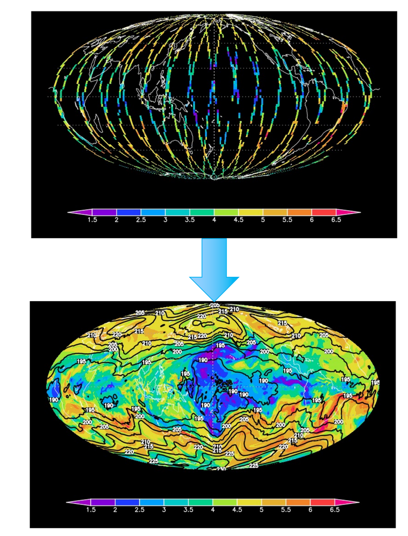
Main Goal for Project

Use NASA's uniformly-gridded, global GEOS model and data assimilation (DAS) products to bridge the gap between the earlier SAGE missions and the SAGE III/ISS products.

What is Data Assimilation

Bayesian method of combining and propagating information from observations in space and time using the governing equations and error estimates

Data Assimilation



Example, 2 January 2016 at 100 hPa.
Top: MLS water vapor.
Bottom: Assimilated MLS water vapor (color) and MERRA-2 temperature (lines)

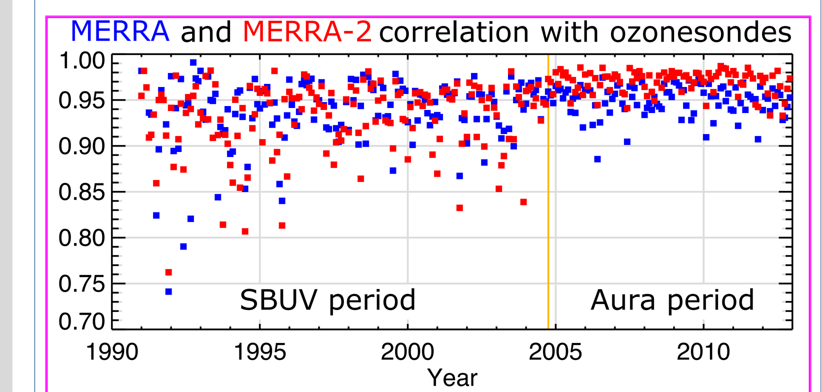
GEOS DAS and CCMM products

MERRA-2: Meteorological reanalysis with assimilated ozone

GEOS-SCREAM: Stratospheric Composition Reanalysis with Aura MLS using GEOS Constituent DAS "CoDAS" framework

MERRA2-GMI: GEOS CCMM with GMI

Changes in observing systems impact reanalysis

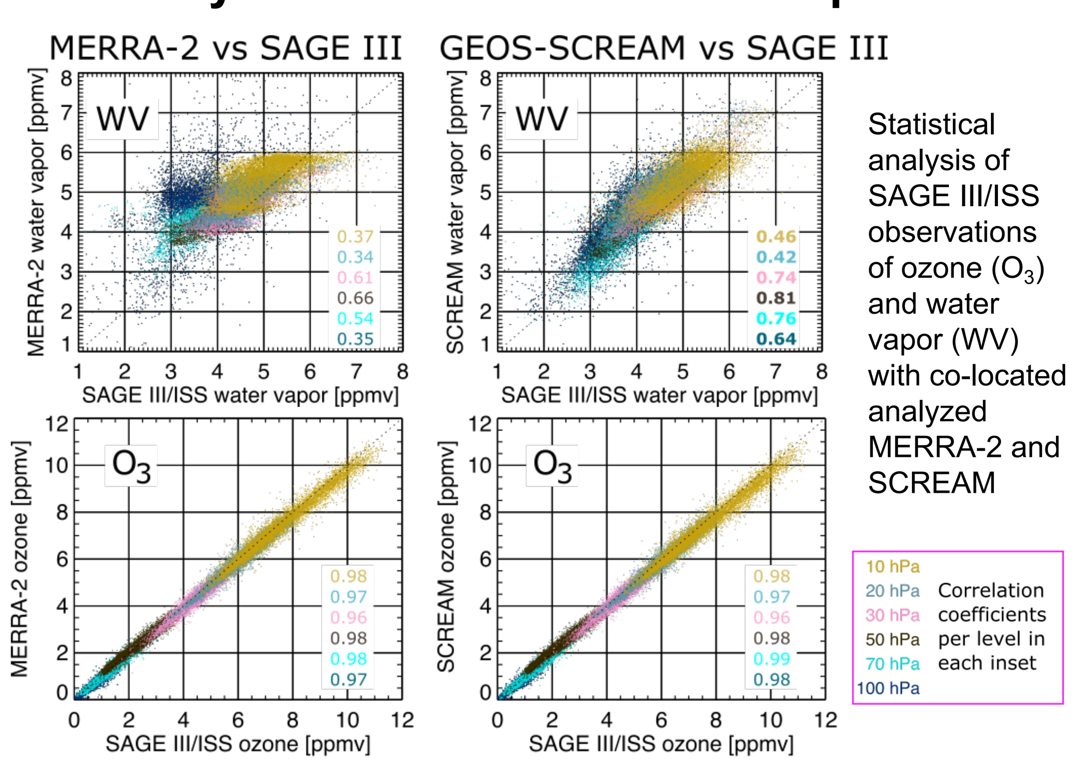


For the ozone observing system, MERRA-2 had one major change when switched from SBUV to MLS and OMI ("Aura period"). In 1998, the introduction of the Advanced Microwave Sounding Unit radiances affected stratospheric temperatures. Figure from Wargan et al., 2017.

Question1: Can we use SAGE II ozone measurements to extend the ozone trend analysis across the 1998 observing system change?

Question 2: Can the assimilation of SAGE water vapor and ozone support trend and climate assessments after the Aura mission?

Trend analysis need well-constrained products



Statistical analysis of SAGE III/ISS observations of ozone (O_3) and water vapor (WV) with co-located analyzed MERRA-2 and SCREAM

SAGE III/ISS vs GEOS Reanalyses

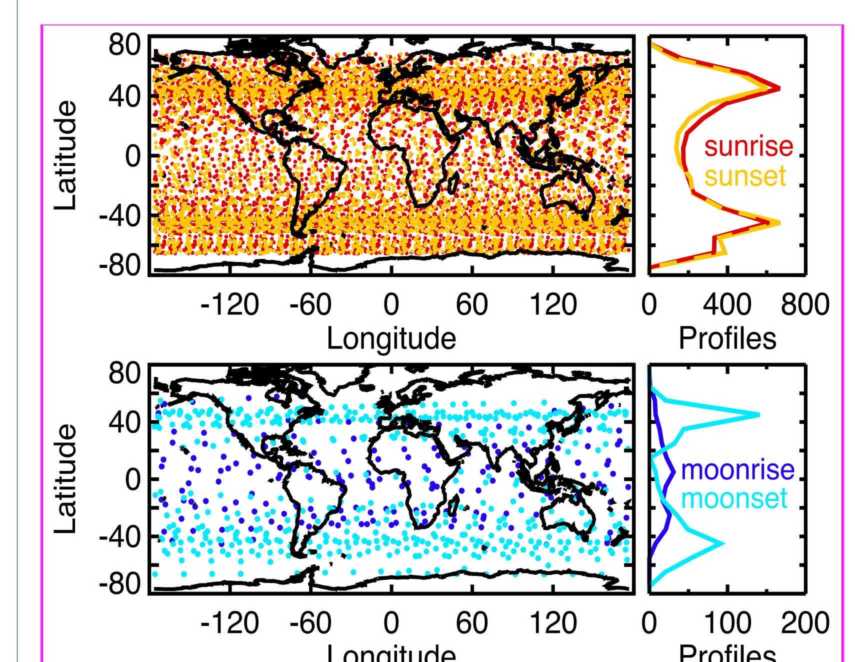
- Reanalysis stratospheric WV historically poor without observational constraint; correlation (r) improves with SCREAM vs SAGE III/ISS
- Despite differences in complexity of stratospheric O_3 chemistry, both reanalyses near perfect r with SAGE

Constituent DA

Chemical data assimilation of O_3 and WV profiles

- SAGE data is likely suitable for assimilation into GEOS using CoDAS framework
- Expectation water vapor will have more impact.

15-30 observations a day from 70 ºS to 70 ºN



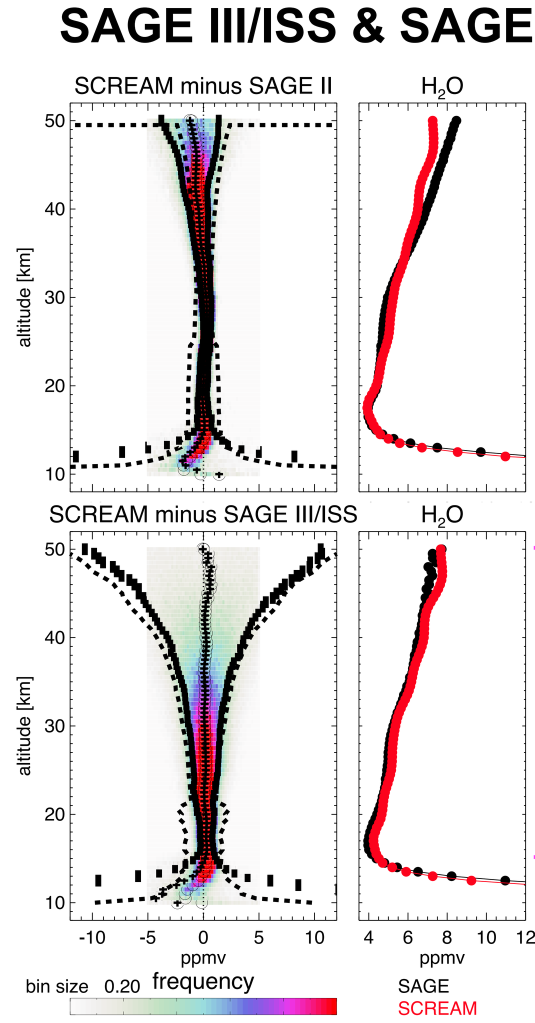
Ozone is available from both solar and lunar occultation measurements while water vapor is only available from the solar occultation.

Lower stratospheric O_3 and WV have chemical timescales long enough that 15-30 solar occultation observations a day can have a positive influence on the analyzed fields. We will use 3DVar assimilation with 6-hour cycle windows, reducing the number of occultations to 3-8 per DAS cycle.

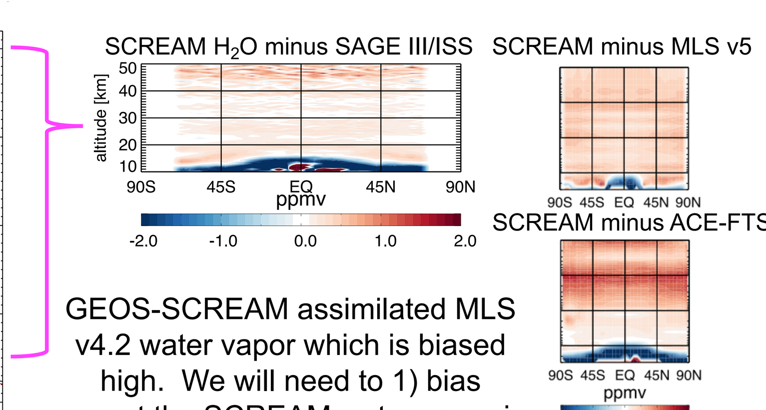
SAGE III/ISS & II Water vapor

- Annual Global Mean stratospheric Water Vapor (H_2O) from the SCREAM reanalysis agrees well with SAGE III/ISS for 2017 through 2020 (2018 shown).
- The vertical profiles for SAGE II are smoothed whereas they are not for SAGE III/ISS, evidenced by the larger standard deviation for SAGE III/ISS above 35 km

SAGE III/ISS & SAGE II Water Vapor retrievals differ



Left figures characterize the difference between SCREAM co-located with SAGE II (2005) and SAGE III/ISS (2018). At each altitude bin is a pdf of "SCREAM minus SAGE" differences (color) and mean (circle) and median (cross) differences. The instrument precision (dotted lines) agree well with standard deviation (thick dashed lines) except at high altitudes and UTLS. The global mean concentrations of water vapor (right) for SCREAM is biased low at high altitudes compared to SAGE II while biased high throughout vs SAGE III/ISS.



GEOS-SCREAM assimilated MLS v4.2 water vapor which is biased high. We will need to 1) bias correct the SCREAM water vapor in line with MLS v5 before we can use it in trend analysis with SAGE water vapor observations and 2) keep in mind that the ACE-FTS measurements (used as independent observations for validation) are also biased in reference to MLS.

Sensitivity experiments

Same set up as GEOS SCREAM, with GEOS SCREAM as initial conditions. Evaluation will be done with ACE-FTS, frost-point hygrometers, sondes, lidar

Control:

1. Coupled Chemistry and Meteorology Model (similar to MERRA2-GMI)
    1. 2016 simulation to test how CCMM may deviate from SCREAM **(running)**
    2. June 2017 to 2021+ control to coincide with CoDAS experiments

GEOS CoDAS:

1. SAGE III/ISS + Aura (MLS and OMI) **(testing begun with this configuration)**
2. SAGE III/ISS + Aura alternative (e.g., OMPS)
3. SAGE III/ISS O_3 and WV assimilated only

GESTAR II SSAI National Aeronautics and Space Administration NASA

E-mail: k.e.knowland@nasa.gov | *Web:* gmao.gsfc.nasa.gov